DOCUMENT RESUME

ED 066 805 EA 004 448

AUTHOR	Hurnard, John R.
TITLE	The Development of a Procedure for Improving Decisions About School Attendance Areas. A Technical Paper.
INSTITUTION	Oregon Univ., Eugene. Bureau of Educational Research and Service.
PUB DATE	Jul 72
NOTE	29p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Attendance; Census Figures; *Computer Programs; Data Bases; Enrollment Projections; Geographic Distribution; Models; On Line Systems; Parent School Relationship; Prediction; Public Schools; School Demography; School Districts; School Location; *School Zoning; *Student Distribution; *Systems Approach
IDENTIFIERS	*School Attendance Boundaries

ABSTRACT

In order to approach an acceptable solution to the problem of defining attendance areas in a school district, decisionmakers need a systematic method of subdividing the district into manipulable components, reliable information regarding the location of children in the district, and a clear understanding of the constraints under which a decision is to be made and the objectives that are being sought. An interactive computer program is a desirable means of speeding progress toward a feasible solution by permitting many alternatives to be examined easily. This article discusses the development of a data base, an interactive program, and a school district model based on U. S. Census blocks. It also comments on the application of the procedure to the analysis of the problem of adjusting attendance area boundaries in a particular school district. A sample computer output is included. (Author)

ED 066805

BUREAU OF EDUCATIONAL RESEARCH AND SERVICE

School of Education

University of Oregon

Eugene, Oregon

THE DEVELOPMENT OF A PROCEDURE FOR IMPROVING DECISIONS ABOUT SCHOOL ATTENDANCE AREAS

by

John R. Hurnard

July 1972

EA 004 448

ED 066805

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY

THE DEVELOPMENT OF A PROCEDURE FOR IMPROVING DECISIONS ABOUT SCHOOL ATTENDANCE AREAS

by

John R. Hurnard

July 1972

THE DEVELOPMENT OF A PROCEDURE FOR IMPROVING DECISIONS ABOUT SCHOOL ATTENDANCE AREAS

John R. Hurnard

Abstract: In order to approach an acceptable solution to the problem of defining attendance areas in a school district, decision makers need a systematic method of subdividing the district into manipulable components, reliable information regarding the location of children in the district, and a clear understanding of the constraints under which a decision is to be made and the objectives which are being sought. An interactive computer program is a desirable means of speeding progress toward a feasible solution by permitting many alternatives to be examined easily. The article discusses the development of a data base, an interactive program, and a school district model based on U. S. Census blocks. It also comments on the application of the procedure to the analysis of the problem of adjusting attendance area boundaries in a particular school district.

An Overview

The problem that initiated the development of the procedure described in this paper was the need to reorganize school attendance boundaries in a school district that found itself with a confused set of imprecisely defined and often overlapping attendance areas for its schools.[1] The problem was just one element in the development of a 20-year master plan for the district. Both the attendance area problem and the master plan itself were approached with the aim of developing decision-making procedures rather than giving final answers to problems.

---

[1]Most of the work leading to the establishment of the data base for the procedure described in this article was carried out by Robert E. Keith (Bureau of Governmental Research and Service, University of Oregon), who also provided the insight into the relevance of U. S. Census procedures and data to the examination of school attendance areas.

One approach to the attendance area problem would have been to obtain a series of pin-map distributions of students by grades and to have visually adjusted boundaries until they produced enrollments corresponding to the capacities of the schools. Apart from being time-consuming to set up, such an approach would not have produced a procedure capable of rapid comparison of alternatives.

It was decided to develop a model of the district in a way that would permit the use of a computer program to facilitate the making of decisions about attendance boundaries. Specifically, rapidity of calculation would permit complete attendance area comparisons to be made for a sequence of constraints because it was found that school officials could not initially specify all the constraints they wished to impose. Thus the first series of iterations used only the initial constraint that enrollments should not exceed the assumed capacity of schools. Using separate applications of the procedure for elementary, junior high, and senior high schools, it was found to be theoretically possible to define attendance areas that matched enrollments in the various schools with their capacities so that the overloading that was occurring in some schools was eliminated. It was found, in fact, that there were several feasible solutions that observed the capacity constraint. Thus it was possible to impose further constraints. The first was the objective of feeding each elementary school uniquely into a junior high school. Previously, sixth grade students from an elementary school in the district could in some cases go on to as many as three different junior high schools. One of the objectives of the district administration was to develop some form of regional administration for K-12 education in the district, with elementary schools feeding uniquely into junior high

schools which in turn fed uniquely into senior high schools. Although senior high school capacity limitations prevented the achievement of this goal in its entirety, the procedure developed for the study did permit considerable rationalization of attendance areas.

An important consideration in the development of this procedure was that it should be a decision-making tool for district administrators. It was to have clearly defined assumptions and was to be flexible enough to encourage administrators to experiment with a variety of alternatives, and to assess the value of each. It was not designed as a one-shot procedure for ameliorating a unique problem but as a continuing decision-making tool.[2]

The study team found that some of the parents of the school district assumed that the team had been making value judgments concerning the objectives of the attendance area rationalization process. It became very difficult to differentiate between the identification of the value components of a decision and the quantification of the values. Patrons found it difficult to separate the role of the planner from the role of the decision maker; they could not grasp the idea that the synthesis of competing objectives was to be carried out by their elected representatives. The study team felt that the school board had to resolve the conflict between the competing demands of, say, the taxpayer for minimal school construction and

---

[2]In a more complete version of the procedure, the third element of the decision-making process--the objectives and preferences--might be fully quantified and expressed as constraint equations so that they could be used with the other two elements--the model of the district and the data on student distribution within the district--to generate a solution using a mathematical programming approach. As implemented in the present study, the procedure stopped short of trying to quantify the preferences and include them mathematically in the decision. However, school district administrators did make some informal estimates of local preference.

the parents for the right to send their children to the nearest school. A planner may suggest how the assessing of public opinion can be carried out and incorporated into the decision model, but it is not his task to assign values arbitrarily. The advantage of laying out the components of a decision clearly is that the decision maker can show how he achieved a solution that was optimal in terms of his perception of the competing preferences of different sub-constituencies.

An Attendance Area Model of a School District

There are two components of a school's attendance area--its geographical extent and the number of children within the area. The smallest conceivable unit available for manipulation would be the individual dwelling. It would be theoretically possible to obtain and store in a file the location of each dwelling unit and the ages of the children in it. But of course such a procedure would be tedious and would ignore the reality that attendance areas are more usually made up of aggregations of dwellings--such as city blocks. A second approach, then, would be to conduct a census by city blocks and to summarize the school-age population within each block. Each block would then be assigned to one school of each level (elementary, junior high, and senior high) and the expected enrollment for a given elementary school, for example, could be obtained by adding together the number of children of elementary school age in each of the blocks assigned to that school. Such a procedure would not differentiate between public and non-public school students unless the census enumeration had noted a child's school affiliation. It would also be based on the assumption that age is an adequate indicator of grade level.

Several problems are associated with the use of city blocks as components of an attendance area. In many parts of a city, groups of blocks seem to hang together as clearly defined larger units, and in outlying parts of a city the term block loses its meaning. Moreover, in the immediate vicinity of a school there is little probability that an area will need to be transferred to another school's attendance area, so that around a school there may be a relatively large area that is not subject to transfer. There would be little point in subdividing such an area.

All this argues for considerable flexibility in defining the geographical units of which attendance areas are to be composed.

A ready-made basis for dividing a school district into clearly defined areas is provided by the U. S. Bureau of the Census. Without attempting a detailed explanation of Census procedures, it could be stated that an urban area may be considered to be divided into blocks, clusters of blocks called block groups, and tracts. The school district for which this procedure was developed was made up of all or part of more than a dozen tracts with a total of over 500 blocks. Most of the tracts contained about three block groups.

The first step in developing a model of the school district was to determine the guidelines to be used in deriving from the U. S. Census blocks somewhat larger geographic units that would lend themselves to manipulation in experimenting with attendance area alternatives. The following guidelines were used:

1. A unit should be a member of only one tract. An obvious reason for imposing this condition was that some census data are available only by tract. If such information is to be applied to smaller units--on an

assumption of equal distribution within a tract--the smaller units need to belong uniquely to one tract.

2. A unit should be made up of an integral number of Census blocks. It was realized that some difficulties might be caused by the U. S. Census requirement that a census block must be bounded by recognizable physical features--usually streets. In the district under consideration, the street pattern is so erratic that some of the census blocks are relatively extensive. But as an initial condition, this requirement was observed. It did become necessary, later in the project, to subdivide one census block arbitrarily. If a district is able to identify the location of students within an extensive block, it should not hesitate to subdivide it as much as necessary.[3]

3. A unit should conform as far as possible to obvious dividing lines between sub-areas, such as major streets and railroad lines.

4. In areas that are midway between adjacent schools, where small adjustments to attendance boundaries may be needed, the units should be relatively small to allow minor changes to be examined.

5. As far as possible, units should be chosen so as to permit easy representation of current attendance areas.

With these criteria in mind, the whole area was divided into 73 aggregations of U. S. Census blocks, to be referred to as attendance "units." An initial state was established in which each attendance "unit" was assigned to one elementary, one junior high, and one senior high school.

---

[3]Some blocks were split by school district boundaries. However, school census and school enrollment data observed the boundaries.

These 73 units constituted the model of the school district. The 17 elementary, 5 junior high, and 3 senior high school attendance areas were seen as combinations of these units. The next step was to find the distribution by age or grade of the school population within each attendance "unit."

The Data Sources

There are essentially two sources of information regarding the distribution of children within a school district: the school itself or an outside agency. Data from the two sources are likely to be collected on different bases.

U. S. Census data. For census data the organizational unit is the census block and the basis of categorization is age at the date of the census. Since it is the "school-age" population that is under consideration, there is no indication of what school, public or non-public, a child attends and no indication of his grade level.[4] Census data are reported with detail inversely proportional to the size of the census unit. For example, at the block level the age distribution of the population is reported by a number of age groups and single ages (0-4, 5, 6-9, 10-13, 14, 15-17, and 18-19) whereas at the tract level the age distribution is reported by single years. The user of the data has to decide whether he wishes to emphasize geographical detail or age detail.

School district data. School district data fall into two categories--data concerning the entire school-age population within the district

[4]These data are collected but are not published by cross-classifications.

(referred to as a "school-age census") and data concerning only those children actually enrolled in public schools. The information is likely to be collected by street address, possibly with both age and grade specified. Clearly, enrollment data provide the most accurate information about the distribution of children currently attending public schools, but if any attempt is to be made to anticipate enrollment in the immediate future, data are required concerning the distribution of pre-school children. It may be necessary, therefore, to combine data sources.

Comparison of data sources. The principal differences between the data sources are that published Census information is associated with a block while school data are associated with an address, and that Census block data are based on age while school data may be based on age or grade or both.

In the district under consideration, three data sources were available: (1) the April, 1970 U. S. Census data; (2) data from a district-wide enumeration of the school-age population (ages 4-19) carried out in October, 1970; and (3) current enrollment data for grades 1-8 as at February, 1972. The third source did not become available until late in the study.

Development of a Data Base

From the two data sources available at the beginning of the study a single data file was developed. A comparison of the U. S. Census data and the data from the school district's own census of school-age children six months later showed that there was a high correspondence as far as age totals for the whole district were concerned. For the 12 age categories (6-17), the average error was less than 3 percent. However, there was

some fluctuation within some of the tracts. The comparison also showed that there had been a severe under-enumeration of 4- and 5-year olds in the school census. It was therefore decided to merge the two data sources, taking the school census figures for children aged 6-17 and the U. S. Census figures for the younger children. The school census figures were preferred for the older age groups because the figures were six months more recent and ages were available by one year increments. In the U. S. Census the geographically most precise data--at the block level--were available only by age groups. It was inevitable that some source other than school census data would be needed to obtain an estimate of the pre-school population since the school census covered children of ages 4-19 only.

In order to merge the two sources--and, indeed, in order to perform the comparisons just discussed--the school census data had to be converted from their address base to a U. S. Census block base.[5]

Address-matching procedure. The U. S. Bureau of the Census, for the first time with the 1970 census, has prepared a street index and a computer program for assigning each address to its appropriate census block. For example, the address of 2240 Elm might be assigned to block 110 of tract 208 because all even numbered addresses on Elm from 2100 to 2300 are defined as belonging to that block. Records containing addresses and data may be matched with an index file to create a data file containing all the information in the original record plus

---

[5]One of the advantages of using a data base developed from Census tract data (or from data shown to be comparable) is that long term population forecasts can utilize forecasts by local planning agencies, which are made by census tracts. This is of particular importance for a school district that may have to decide on the location of new schools. Conceivably, a district's overall school population could remain stable for a decade, but within the district there might be a considerable shift of population. The no-growth prognosis for the district as a whole might be misleading because, in actual fact, growth in one part of the district could necessitate the building of additional schools in that area.

that record's block assignment. Individual records may then be counted to produce block summaries for the levels of any variable in the record. For example, the distribution of children by age in block 208 110 could be obtained by counting the number of children of each age whose address placed them in block 208 110. Addresses based on rural routes or box numbers are not amenable to processing using the address-matching procedure. They have to be hand assigned or provision has to be made to automatically assign them to an arbitrary block.

Assumption regarding children aged 0-4. The data base was obtained by merging age summaries for children aged 0-4 and children aged 5 from the U. S. Census block information with the age summaries by single year increments for the older children from the school census information. Since the school data had been converted to a block basis from an address basis, the whole data set was based on the school-age population's distribution by U. S. Census block.

It should be noted that some precision was lost in using U. S. Census block data for ages 0-4. Since these figures were available only as a single category, some assumption had to be made about the distribution of the population through this five year range. For the total district, the assumption that 20 percent of the group would be in each category could easily be made.[6] But there was some variation in individual tracts. Since tract data were available by single year increments, there were two alternatives available. It could be assumed that the age distribution of children within a block was proportional to the distribution within the tract of which the block was a member; or it

---

[6]For the district as a whole, the distribution of children under 5 was as follows: Less than 1, 20.18 percent; 1 year old, 20.03 percent; 2 years old, 20.10 percent; 3 years old, 19.76 percent; and 4 years old 19.93 percent.

could be assumed that the district wide distribution--approximately 20 percent for each year within the range--could be applied to the individual block. The second assumption was adopted. One reason for preferring to use the less precisely defined block data rather than the tract data was that the school district was not made up of an integral number of census tracts. A few tracts fell only partly within the boundaries of the district. Use of tract data would have required some knowledge of the proportion of the tract population living in the blocks that fell within the school district.

To this point, then, two sets of data have been described. One set consists of the definition of 73 attendance "units" to include all the U. S. Census blocks in the school district. The second data set summarizes the population (ages 0-17) in each block. Perhaps it would be desirable to point out what the second data set does not contain. It does not distinguish between children who are in public school, non-public school, or not in school--it is exclusively a summary of the distribution of children under 18 years old in the district.[7]

The data set does not contain any indication of grade affiliation. Consequently, it has to be assumed that enrollment by grades can be approximated by defining each grade as an age category. For example, 7-year old children are defined to be second graders. This assumption is examined later when enrollment and census data are compared.

---

[7]Comparison of actual enrollment figures with school-age population data gives an indication, in district-wide terms, of the percentage of school-age children attending public school. While the percentage varies with different age groups and for different reasons--such as the existence of a parochial school in the case of the younger children or a high drop-out rate in the case of the older students--the use of school-age figures seems to be justified as they give an over-estimate of current enrollment and consequently give some hedge against random fluctuation. The assumption that the percentage of school-age children attending public school is the same throughout the district may not be tenable if a non-public school has strong support in one area.

For a district with a flexible approach to grouping children for instruction, there would probably be little value in using grade as the basis of classification.

Current Enrollment Data

In addition to the two data sources already discussed, current enrollment data were supplied by the school district later in the study. These data were based on February, 1972 figures and were thus almost two years more recent than the U. S. Census data. The figures were for students in public school from the first through the eighth grade, with individuals classified by grade and age.

These records were processed through the address-matching program and summarized by U. S. Census blocks. A series of comparisons was made to see how well the age-grade assumption stood up to scrutiny and to see whether there had been any shift in the population during the period. On a district-wide basis the use of age as an indication of grade proved to be acceptable although there were of course variations from tract to tract.[8]

A full discussion of the comparisons is not appropriate at this point, since the purpose of this paper is to describe the general procedures used in the study rather than to examine the implications associated with the use of different data sources.

---

[8]The total number of children in a particular grade could be predicted from the age totals for the district as a whole because there were approximately the same number of children in each of the grades and the distribution of children by age within a grade tended to follow a definite pattern. For example, the ratio of 6-year olds to 7-year olds to 8-year olds in the first grade was 55:40:5. For the second through the sixth grade, the ratios for the equivalent three ages were 60:36:4, 59:37:4, 61:36:2, 58:38:3, and 63:34:3 respectively.

Before proceeding to an examination of the manipulation of data, a short summary might be in order. The school district for which the procedure was developed serves between thirteen and fourteen thousand students in 17 elementary, 5 junior high, and 3 senior high schools. The capacities of the elementary schools ranged from about 275 to 575 students, the junior highs from about 400 to 875 students, and the senior highs from about 1350 to 1650. The year before the study was commissioned, the district had been formed through the unification of 1 high school and 4 elementary school districts. In the current school year there was overcrowding at 3 elementary schools and 1 senior high school, with one junior high school operating at about 400 students below capacity. Historical and topographical considerations had combined to produce an inefficient distribution of school buildings throughout the newly consolidated district. The rationalization of attendance areas, primarily to equalize a school's enrollment and its capacity, was the main purpose of that aspect of the study with which this paper is concerned.

Manipulation of Data

The intention of the study team was to develop a decision-making procedure for the administration rather than to make specific recommendations regarding possible solutions. The decision mechanism was to be an interactive computer program that would work with the model of the district and the data base and would quickly generate summaries of the enrollment for each school according to different attendance area alternatives. The decision to use an interactive or real time system was prompted by the wish to be able to work quickly toward a feasible solution by means of a series of trials. A batch processing approach would have been appropriate if only one or two runs were contemplated or, more significantly, if all the constraints could have been clearly explicated

initially. It was assumed that new constraints would emerge as unanticipated consequences of certain attendance area alternatives became apparent. The program was designed to be kept available on-line so that a decision maker could quickly check the result of a boundary modification.

Apart from the data base, the interactive program needs a set of initial conditions and definitions. Each attendance "unit" has to be assigned to one elementary, one junior high, and one senior high school, and the schools have to be identified by a sequence number within each type--elementary, junior high, and senior high. A set of parameters--the age definitions of the schools--has to be established. For example, the elementary schools might initially be defined as ages 6-11 (i.e., grades 1-6), junior high schools as ages 12-13, and senior high schools as ages 14-17. Later it might be desirable to redefine elementary schools as kindergarten through fifth grade, or ages 5 through 10. Other possibilities associated with the program's capability of redefining schools by age will be discussed later.

Before the data base can be used in the program, it has to go through two processing stages. First, the census blocks have to be combined into attendance "units," as previously defined. An index file stores the definition of each attendance unit, with its identifying number, by specifying which census blocks are contained in that unit. At the same time, each school has to be given an initial set of attendance "units." The procedure combining the census blocks into attendance units adds together the student population figures from each of the blocks, giving a distribution by single years for each of the attendance "units."

The index file for census blocks is organized thus:

Attendance "unit"	U. S. Census Blocks
20801	208101 208102 208110 208111 208112 208201 208202 208203 208301 208303
20802	208103 208104 208105 208106 208113 208114 208115 208204 208205 208206 208302 208304
. . .	. . .

That file is used to control the summing of data from each block into a data file for each "unit." The unit data file is organized thus:

Attendance "unit"	Distribution of population by age												
	0	1	.	.	.	8	9	10	.	.	.	17
20801	10	10	.	.	.	9	12	14	.	.	.	11
20802	12	12	.	.	.	15	15	12	.	.	.	18
. . .	. . .											

The second processing stage involves linking the units together in terms of school attendance areas as initially defined. For each school in turn, a linked list is created in the "unit" file by linking, by means of pointers, all the units associated with that school's attendance area. The product of this process is an extended version of the unit data file called the control matrix.

The control matrix has four sets of information for each "unit."

1. The identification number of the unit (for example, 20801 or 20802);
2. The distribution of the population in that unit by years (ages 0-17);

3. The current association of the unit with one school of each type. For example, 2, 4, 1 would indicate that the unit is currently associated with the attendance areas of elementary school #2, junior high school #4, and senior high school #1.
4. Three pointers, one to each of the next units in the three linked lists for schools of each type. Continuing the example given above, the final three elements in the record might be 36, 20, 0. This would indicate that the next unit associated with elementary school #2 is the unit found in the 36th record of the file; the next unit for junior high school #4 is to be found in the 20th record; and the present unit is the last unit in the list of units associated with senior high school #1.

This control matrix is kept on a random access file. A short sequential file contains the names of the schools and the current value of certain parameters, notably the present age definition of each school type and the set of pointers to the first element in each linked list.

The Interactive Program

The program for manipulating the data was written in FORTRAN for the PDP-10 computer at the University of Oregon. The program was designed to be self-explanatory; that is to say, the user is given complete instructions regarding the use of the program and its options as the program is executed. In general terms, the program first reads current values of the parameters from the sequential file; then it lists the options available, interacts with the user as he selects the options he needs, as often as he wishes, and makes necessary changes to the control matrix on the random access file as the user moves attendance units from one school to another. When the user has finished,

the program writes the current parameter values on the sequential file.

Specifically, the program enables the user to do the following:

1. List the current set of units associated with one school or with all schools of one type.
2. List the school names and their identification numbers.
3. Change the age definition of schools. By typing in the range of ages associated with each school type, the user modifies the age parameters.
4. Print a summary of the control matrix. Since this is a long file, a formated version is placed in a file ready to be directed to the line printer rather than to the teletype. After finishing his interaction with the program, the user follows the usual procedure to queue this file to the line printer.
5. Search for the current association of a particular unit with the three types of schools. The user gives the number of the unit of whose current school affiliations he is uncertain. The program searches the control matrix for the unit and prints out the identification numbers of the elementary, junior high, and senior high schools with which it is affiliated.
6. Print out an enrollment summary for a given school or for all schools of a given type. If the user is interested in the enrollment for the next five years in elementary school #3 with its attendance area as currently defined, and if elementary schools are currently defined as containing children of ages 6-11, the program will go to the record containing the unit indicated by the pointer for elementary school #3. Since elementary schools, in the 1972-73 school year,

contain children who were between four and nine years old when the data were collected in 1970, the program will find the number of children aged 4-9 in this attendance unit. To obtain the enrollment for 1973-74, the program will sum the children whose ages were between 3 and 8 in the year the base data were collected, and so on for each year through 1976-77. Then the program moves to the record containing the next unit in the linked list of units for this school's attendance area. The appropriate age classifications are accumulated and added to the totals already obtained in the previous record, and so on until the last record in that school's linked list has been processed. The complete enrollment summary is then printed out. If enrollments are required for all schools of a certain type, the program loops through the procedure once for each school. The user would not expect to place much reliability on the enrollment estimates for the later years in the five year period, but the figures do give an indication of the influence of age-cohort variation on the school's enrollment if the effect of migration is omitted.

7. Transfer a unit from one attendance area to another. This is perhaps the most important and most frequently used feature of the program. The user specifies the unit he wishes to transfer, the type of school involved, and the identification numbers of the schools from and to which he wishes to transfer the unit. By adjusting pointers the program simply modifies the appropriate linked lists and changes the parameters that specify the number of units associated with the two schools involved. It should be noted that the transfer is performed for only one type of school at a time. The user is not committed to making an adjustment to, say, junior high school attendance boundaries, just because he adjusts elementary school boundaries.

8. The final option is to quit. As has already been pointed out, this causes a sequential file to be written containing current values of the parameters so that the user can take up again at the same point.

If the user wishes to examine several widely differing sets of attendance boundaries, he might wish to retain several control and parameter files, renaming them appropriately so that the relevant onesare read by the manipulative program.

One of the useful features of the program not fully discussed already is the age-change provision. If it is desirable to isolate a particular grade (or age group) for examination--say kindergarten--the user simply redefines elementary schools temporarily to contain children from age 5 to age 5. Similarly, the size of the freshman class at each high school could be examined by redefining high schools to include students from age 14 to age 14. Or the distribution of high school freshmen could be examined by redefining elementary schools to include students from age 14 to age 14.

Additional Benefits Associated with the Model

Organizing data about a school district in terms of U. S. Census blocks or some other clearly defined small units means that the user can take advantage of computer-related plotting procedures.

If geographical coordinates are assigned to the centroid of each block, it is possible to plot the distribution of a particular sub-set of the population. For example, in the study under discussion, the school district was supplied with a summary of its present school population by grades. A series of plots, printed by the CALCOMP plotter on semi-transparent paper, gave the distribution of children at each grade level by census blocks. Superimposing the plot on a standard U. S. Census map gives a visual representation of the

distribution of the children. At the centroid of each block a number is printed, indicating the number of enrolled students of a particular grade in that block.

The existence of a data file with block assignments for each student means that once new attendance areas have been defined in terms of blocks, a listing of students by grades can be immediately printed out for each of the schools by the new attendance areas. Thus, not only can the total enrollment be easily calculated for any hypothetical attendance area, but the actual listing of students in that area can readily be obtained.

It should be noted that the production of such a listing would only be appropriate when enrollment data were being used. While the assumption of age-grade equivalence gives an adequate picture of the grade distribution of children in the district as a whole, it almost certainly does not give sufficient accuracy by smaller units of analysis to warrant its use for any purpose requiring precise prediction. While total enrollment in a school might be closely approximated by using the age-grade equivalence assumption, the prediction of enrollment in individual grades within a school would be at best a precarious undertaking using age-based data. The most powerful use of the procedure described in this article would be with enrollment data based on grades, with the addition of carefully collected data on pre-school children. Such additional data should be based on the age of the child at the district's official cut-off birth date for entry to the first grade.

The procedure is very flexible. In the first place, the data in the control file could be modified, when enrollment projections are being produced, by the introduction of some net migration assumptions for the district as a whole or for individual tracts within the district. Moreover, although U. S. Census data and the U. S. Census model of the district form an obvious

starting point, there is no reason why modifications should not be introduced. For example, the model might be improved, especially if the district is not completely urbanized, by arbitrarily defining smaller blocks or units wherever the U. S. Census blocks are excessively large or wherever the school district includes enumeration districts.[9] A district might choose not to use U. S. Census blocks at all. The district could be broken down arbitrarily into appropriately defined and numbered units, and student records could include the unit identification number as well as the address. Such an approach to record keeping would enable the address-matching procedure to be by-passed.

U. S. Census block designations will tend to change from census to census, so that although the use of census data and blocks may be useful shortly after a census year, the census model loses viability with time. What is needed, then, is a procedure that is inspired by, but not dependent on, the Census model. Retaining compatibility with the Census procedures as far as possible would permit comparisons to be carried out, as soon as data from a new census became available, between school age population and school enrollment figures.

Careful annual updating of enrollment and improvement of the model of the school district as new housing areas are opened up, together with the availability of an interactive program to manipulate the data, would permit

---

[9]Census enumeration districts are the equivalent of block groups in non-urban areas. Since they are not further subdivided, they tend to be quite extensive. Consequently, there is a severe loss of information about the geographical distribution of population within an enumeration district if all individuals are visualized as residing at the centroid of the enumeration district.

a district to monitor year to year population shifts and to continually examine the implications of possible attendance boundary changes. Thus the procedure has potential as a continuing planning tool as well as offering a method of solving immediate problems.

If data concerning socio-economic or racial characteristics of the population were used as well as or in place of the age/grade data, the same procedure could be used to examine alternatives aimed at achieving a certain mix of students in each school.

The remaining pages of this paper contain sample output of the computer program. The output was selected merely to illustrate the options available in using the program, not to illustrate the solution of a particular problem.

SAMPLE OUTPUT

```
TYPE 1 IF YOU WISH THE OPTIONS PRINTED;
TYPE 2 IF YOU ARE ALREADY FAMILIAR WITH THE
CODING.

1

OPTIONS:

1.  PRINT EXISTING DISTRIBUTION OF BLOCKS IN TYPE 1
    (USUALLY DEFINED AS ELEMENTARY) SCHOOLS.
2.  PRINT DISTRIBUTION IN TYPE 2 (JUNIOR HIGH) SCHOOLS.
3.  PRINT DISTRIBUTION IN TYPE 3 (SENIOR HIGH) SCHOOLS.
4.  LIST SCHOOL NAMES AND THEIR ID NUMBERS.
5.  CHANGE WEIGHTS FOR THE DISTRIBUTION OF DATA
    FOR AGES 0 - 4.
6.  PRINT CONTROL MATRIX.
7.  CHANGE THE AGE DEFINITION OF SCHOOL TYPES.
8.  MOVE BLOCKS FROM ONE SCHOOL TO ANOTHER.
9.  PRINT AN ENROLLMENT SUMMARY.
10. FIND WHICH SCHOOLS A GIVEN BLOCK IS
    ASSOCIATED WITH AT THE MOMENT.
11. QUIT.
```

TYPE IN AN OPTION NUMBER.
4

ID	SCHOOL	TYPE	WITHIN ID	NO. OF BLOCKS	POINTER
1	SCHOOL A	1	1	2	3
2	SCHOOL B	1	2	3	70
3	SCHOOL C	1	3	5	59
4	SCHOOL D	1	4	6	33
5	SCHOOL E	1	5	6	66
6	SCHOOL F	1	6	3	73
7	SCHOOL G	1	7	7	38
8	SCHOOL H	1	8	5	47
9	SCHOOL I	1	9	3	43
10	SCHOOL J	1	10	5	32
11	SCHOOL K	1	11	3	26
12	SCHOOL L	1	12	4	31
13	SCHOOL M	1	13	2	52
14	SCHOOL N	1	14	2	65
15	SCHOOL O	1	15	4	56
16	SCHOOL P	1	16	7	69
17	SCHOOL Q	1	17	6	51
18	SCHOOL R	2	1	6	56
19	SCHOOL S	2	2	27	73
20	SCHOOL T	2	3	13	66
21	SCHOOL U	2	4	7	32
22	SCHOOL V	2	5	20	47
23	SCHOOL W	3	1	23	50
24	SCHOOL X	3	2	31	17
25	SCHOOL Y	3	3	19	60

TYPE IN AN OPTION NUMBER.
9

THE SUMMARY MAY BE FOR AN INDIVIDUAL SCHOOL OR FOR
ALL SCHOOLS OF A GIVEN TYPE. TYPE IN 1 FOR
A SUMMARY OF AN INDIVIDUAL SCHOOL, 2 FOR A GROUP SUMMARY.
1

GIVE SCHOOL TYPE AND NUMBER WITHIN TYPE; FOR EXAMPLE, 2,4
3,3

IF A CORRECTION FACTOR IS DESIRED
--TO ADJUST ALL ENROLLMENTS--
TYPE IT IN; FOR EXAMPLE, 1.04 OR 0.955.
IF NO CORRECTION IS REQUIRED, TYPE 1.0
1.0

ENROLLMENT BY YEARS: (AGES 14 TO 17; CORRECTION FACTOR 1.000000)

SCHOOL	71-72	72-73	73-74	74-75	75-76	76-77
SCHOOL Y	1555	1561	1553	1568	1584	1564

ANY MORE ENROLLMENT SUMMARIES? YES OR NO.

NO

TYPE IN AN OPTION NUMBER.
3

DO YOU WISH TO DO A BLOCK SUMMARY OF ALL SCHOOLS OF TYPE 3,
OR ONLY OF ONE SCHOOL? TYPE 99 FOR ALL SCHOOLS
OR TYPE 1, 2, . . . ETC. TO IDENTIFY THE
SELECTED SCHOOL WITHIN THIS TYPE.
99

SCHOOL: SCHOOL W
BLOCKS:

21624	21623	22150	22180	21617	21616	21615	
21614	21613	21612	21532	21531	22110	22162	22170	22232
22231	22222	22213	22212	22161	21540	21520		

SCHOOL: SCHOOL X
BLOCKS:

21113	21130	21120	21611	21006	21007	21008	
21622	21625	22211	22221	21621	21560	21550	21512	21511
21115	21114	21112	21111	21005	21004	21003	21002	21001
20904	20903	20902	20901	20802	20801			

SCHOOL: SCHOOL Y
BLOCKS:

22130	22140	22120	22000	21832	21831	21820	
21810	21700	21443	21442	21441	21430	21420	21410	21302
21301	21202	21201						

```
TYPE IN AN OPTION NUMBER.
10

WHAT IS THE BLOCK NUMBER?
21540

BLOCK  21540 IS IN SCHOOL  7 OF TYPE 1


BLOCK  21540 IS IN SCHOOL  2 OF TYPE 2


BLOCK  21540 IS IN SCHOOL  1 OF TYPE 3


TYPE IN AN OPTION NUMBER.
8


TYPE IN TRANSFER INFORMATION IN THIS FORM:

  BLOCK #, TYPE OF SCHOOL, SCHOOL WITHIN THIS TYPE FROM WHICH
    TRANSFER IS BEING MADE, SCHOOL WITHIN THIS TYPE TO WHICH
  TRANSFER IS BEING MADE.

  FOR EXAMPLE: 110,2,3,1 REQUESTS A TRANSFER OF BLOCK 110 FROM
SCHOOL 3 TO SCHOOL 1 WITHIN TYPE 2.

20901,3,3,1

ERROR:  BLOCK NOT PRESENTLY ASSOCIATED WITH THE
INDICATED SCHOOL.

ANY MORE TRANSFERS? YES OR NO.
YES

INPUT TRANSFER DATA AS BEFORE.

20901,3,2,3

ANY MORE TRANSFERS? YES OR NO.
YES

INPUT TRANSFER DATA AS BEFORE.

20902,3,2,3

ANY MORE TRANSFERS? YES OR NO.
NO
```

```
TYPE IN AN OPTION NUMBER.
3

DO YOU WISH TO DO A BLOCK SUMMARY OF ALL SCHOOLS OF TYPE 3,
OR ONLY OF ONE SCHOOL?  TYPE 99 FOR ALL SCHOOLS
OR TYPE 1, 2, . . . ETC. TO IDENTIFY THE
SELECTED SCHOOL WITHIN THIS TYPE.
99

SCHOOL: SCHOOL W
BLOCKS:          21624   21623   22150   22180   21617   21616   21615
21614   21613   21612   21532   21531   22110   22162   22170   22232
22231   22222   22213   22212   22161   21540   21520


SCHOOL: SCHOOL X
BLOCKS:          21113   21130   21120   21611   21006   21007   21008
21622   21625   22211   22221   21621   21560   21550   21512   21511
21115   21114   21112   21111   21005   21004   21003   21002   21001
20904   20903   20802   20801


SCHOOL: SCHOOL Y
BLOCKS:          20902   20901   22130   22140   22120   22000   21832
21831   21820   21810   21700   21443   21442   21441   21430   21420
21410   21302   21301   21202   21201
```

TYPE IN AN OPTION NUMBER.
9

THE SUMMARY MAY BE FOR AN INDIVIDUAL SCHOOL OR FOR
ALL SCHOOLS OF A GIVEN TYPE. TYPE IN 1 FOR
A SUMMARY OF AN INDIVIDUAL SCHOOL, 2 FOR A GROUP SUMMARY.
2

GIVE THE SCHOOL TYPE--1,2, OR 3.
3

IF A CORRECTION FACTOR IS DESIRED
--TO ADJUST ALL ENROLLMENTS--
TYPE IT IN; FOR EXAMPLE, 1.04 OR 0.955.
IF NO CORRECTION IS REQUIRED, TYPE 1.0
1.0

ENROLLMENT BY YEARS: (AGES 14 TO 17; CORRECTION FACTOR 1.00000)

SCHOOL	71-72	72-73	73-74	74-75	75-76	76-77
SCHOOL W	1435	1438	1423	1365	1379	1367
SCHOOL X	1470	1490	1456	1446	1438	1441
SCHOOL Y	1773	1794	1770	1809	1838	1819

ANY MORE ENROLLMENT SUMMARIES? YES OR NO.

NO

TYPE IN AN OPTION NUMBER.
7

ENTER THE AGES, GIVING LOW AND HIGH FOR TYPE 1
SCHOOLS FIRST, THEN FOR TYPE 2, AND FINALLY FOR TYPE 3.
FOR EXAMPLE: 5,10,11,14,15,17
6,11,12,14,15,17

THE CHANGES HAVE BEEN MADE.

```
TYPE IN AN OPTION NUMBER.
9

THE SUMMARY MAY BE FOR AN INDIVIDUAL SCHOOL OR FOR
ALL SCHOOLS OF A GIVEN TYPE.  TYPE IN 1 FOR
A SUMMARY OF AN INDIVIDUAL SCHOOL, 2 FOR A GROUP SUMMARY.
2

GIVE THE SCHOOL TYPE--1,2, OR 3.
3

IF A CORRECTION FACTOR IS DESIRED
--TO ADJUST ALL ENROLLMENTS--
TYPE IT IN; FOR EXAMPLE, 1.04 OR 0.955.
IF NO CORRECTION IS REQUIRED, TYPE 1.0
1.0

ENROLLMENT BY YEARS: (AGES 15 TO 17; CORRECTION FACTOR  1.000000)

SCHOOL          71-72   72-73   73-74   74-75   75-76   76-77
-------------------------------------------------------------

SCHOOL W         1103    1080    1086    1027    1033    1021
SCHOOL X         1082    1120    1129    1085    1058    1068
SCHOOL Y         1321    1331    1330    1355    1357    1375

-------------------------------------------------------------


ANY MORE ENROLLMENT SUMMARIES?  YES OR NO.

NO

TYPE IN AN OPTION NUMBER.
6

THE CONTROL MATRIX IS AVAILABLE ON FILE MATRI.DAT.

TYPE IN AN OPTION NUMBER.
11

THE FILE SUMUP.DAT HAS BEEN WRITTEN.
```